2.8 ON-BOARD DECEPTIVE ECM

Deceptive ECM is the generation of signals that deceive the signal processing logic of a threat target tracking radar in terms of angle, range, or velocity. Deceptive ECM techniques can be either active or passive. Active jammers either amplify and radiate electromagnetic energy received from the threat (or victim) radar, or generate and radiate signals designed to appear like actual target returns. Active deception techniques simulated in *RADGUNS* are simple repeater, range gate walk-off, inverse gain, and swept audio. Passive ECM devices reflect, absorb, or refract radar energy to create clutter and false targets, and techniques include chaff, decoys, and other non-emitters. *RADGUNS* simulates a passive reflector ECM technique.

This FE addresses on-board deceptive ECM, where jamming equipment is carried by the target aircraft and remains on-board the aircraft during employment. On-board jamming is a type of self-screening, or self-protection jamming (SPJ). Other SPJ devices can be carried by an aircraft for external (off-board) deployment, as in the case of expendable and towed jammers. Another type of jamming is support or standoff jamming, in which the jamming source is a separate platform from the target aircraft. Off-board Deceptive ECM is addressed in FE 1.3.2.2, Section 2.9; Standoff Deceptive ECM is discussed in FE 1.3.2.3, Section 2.10.

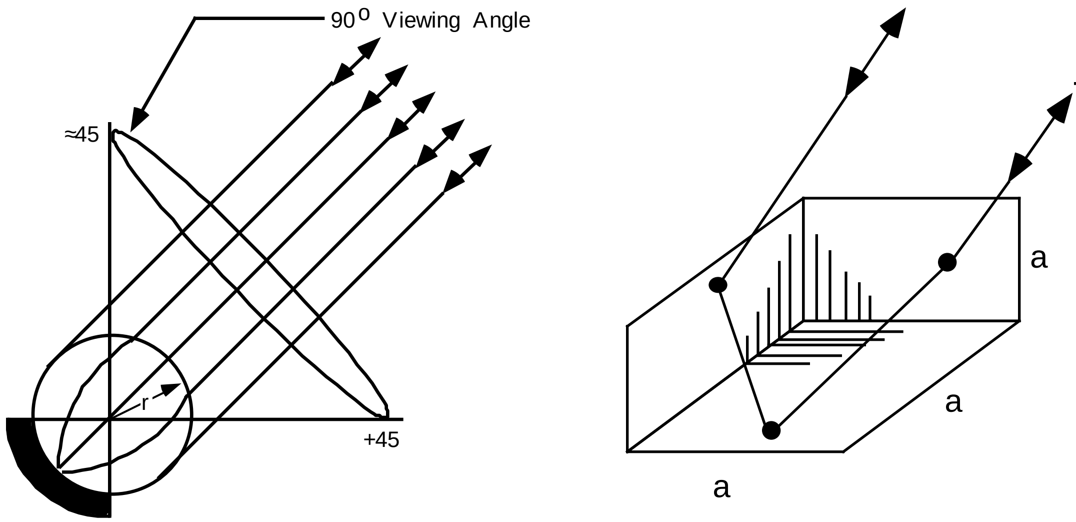
RADGUNS allows the user to characterize the jammer location by specifying a jammer class: on-board, off-board (towed or expendable), or standoff. While the *RADGUNS* model imposes no limitations in combining a jammer class with a jamming technique, some combinations would be less effective in an actual tactical situation. For example, a reflector would not be likely to be employed on-board a target aircraft—it would only enhance a threat system's ability to engage that target. Nevertheless, all of the available deceptive ECM techniques are described in this section, and no attempt is made to judge the tactical utility of particular ECM systems.

The following paragraphs provide a general description of each of the deceptive techniques available in *RADGUNS*:

Passive Reflector. Passive reflectors produce an effective target gain. They can be used as a support ECM technique aboard expendables or drones to enhance their RCS so that they will be perceived as larger attack aircraft, forcing threat radars to expend resources on their acquisition and tracking. Passive reflectors can also be towed or launched from aircraft to provide additional targets that serve to reduce threat resources dedicated to tracking the actual target.

Two examples of passive reflector devices are a Luneberg Lens reflector and a corner reflector. A Luneberg Lens focuses radar energy through a lens to a point on a cap reflector as shown in Figure 2.8-1a. The reflected energy then retraces the path through the lens and is radiated back in the direction from which it came. A corner reflector usually consists of three perpendicular conducting surfaces as shown in Figure 2.8-1b. Radar energy incident on the surface will experience three reflections before being reradiated in the direction from which it arrived. Chaff can be employed as a passive reflector; however, this technique is not modeled in *RADGUNS*.

Simple Repeater. A simple repeater amplifies, delays, and retransmits the received radar pulse train, providing a false target return that is larger in amplitude than the true return, and whose range is usually beyond that of the actual target. This technique can also be employed by towed and expendable jammers.



a) Luneberg Lens Reflector b) Square Corner Reflector

FIGURE 2.8-1. Passive Reflector Devices.

Range Gate Walk-off. Range gate walk-off (RGWO) is a more complex repeater technique used against automatic range tracking radars. The jammer receives the radar's signal, amplifies it with a minimum delay, and retransmits it to provide a strong return to the radar. The amplified return causes the radar receiver gain to decrease due to automatic gain control (AGC) circuitry, thereby suppressing the true target signal and capturing the repeater signal in the range gate. The time delay of the repeated signal is then gradually increased at a specified walk-off rate. Once the radar range gate is pulled completely off the target, jamming is terminated and the threat radar range gate is left with no signal to process. This technique repeatedly forces the use of manual reacquisition modes, affecting the accuracy and timeliness of fire control and guidance solutions.

Inverse Gain. Inverse gain is an angle-deception technique used against conical scan (CONSCAN) radars, which track targets by rotating the transmit antenna beam at a constant angle around the boresighted target position. This causes the signal return amplitude to vary sinusoidally at the scan, or rotation, frequency. The magnitude of the variation is proportional to the magnitude of the error, and the phase of the variation indicates the direction of the error. This error information is used to reposition the transmit antenna so that the target is centered within the conical scan volume. An inverse gain jammer transmits a 180-deg out-of-phase signal that is gated on during the expected target return's minimum amplitude periods. This effectively removes or alters the scan-induced modulation of the target return pulses at the radar receiver as shown in Figure 2.8-2. Inverse gain jamming requires *a priori* knowledge of the radar's transmit antenna scan frequency (or range of frequencies). (For more information on inverse gain jamming, see Reference 20, page 706.)

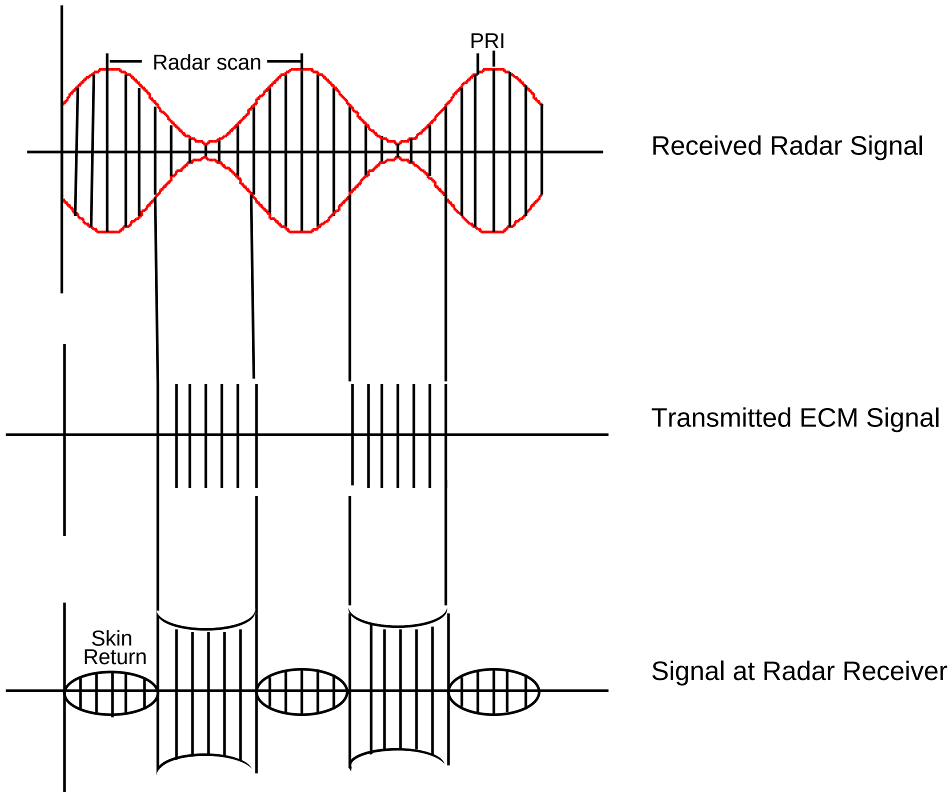


FIGURE 2.8-2. Inverse Gain Waveforms.

<u>Swept Audio</u>. Swept audio is an angle-deception technique that is used when the exact scan rate is not known, or against Conical Scan on Receive Only (COSRO), Track-while-Scan (TWS), or COSRO-like monopulse radars where the scan rate can be bounded. The ECM output signal is either a noise source or pulse repeater output that is amplitude modulated with a square wave that sweeps in frequency over the expected scan frequency range of the tracking radar. The frequency modulation waveform implemented in *RADGUNS* is a positive sweeping sawtooth as shown in Figure 2.8-3a. This sawtooth waveform produces a jammer output signal envelope that consists of a train of pulses of decreasing width as shown in Figure 2.8-3b. If the frequency of the amplitude modulating square wave is sufficiently close to the scan frequency of the target tracking radar (i.e., each jammer on-off cycle has a duration sufficiently close to the victim radar's scan period), and this occurs for a sufficiently large fraction of the jammer's frequency modulation period, the extraneous signal may cause an error in the radar's computation of the angle at which the maximum target signal amplitude occurs. (For more information on swept audio jamming, see Reference 20, page 898.)

In *RADGUNS*, a noise source is employed as the ECM signal modulated by the swept square wave.

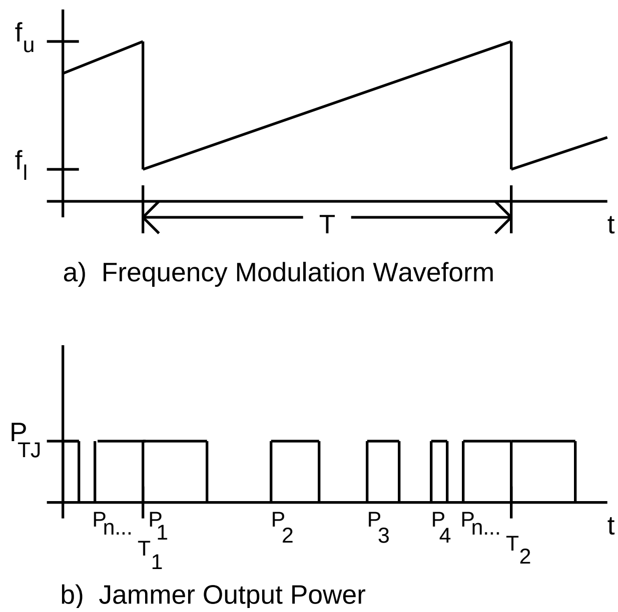


FIGURE 2.8-3. Swept Audio Waveforms.

2.8.1 Functional Element Design Requirements

This section contains the design requirements necessary to implement the simulation of on-board deceptive ECM in *RADGUNS*.

a. *RADGUNS* will calculate the received signal power of an on-board deceptive jammer using the basic radar range equation, including effects of jammer power, jammer gains and losses, directional radar receiver gains, and other standard radar parameters.

b. *RADGUNS* will have the capability of simulating up to ten jamming sources in any engagement.

c. *RADGUNS* will simulate both preemptive and reactive jamming tactics. A jammer employing a preemptive tactic will be active during a predetermined time block. In the reactive jamming case, active jamming will occur only when the radar signal at the jammer receiver exceeds a user-specified jammer receiver threshold.

d. Deceptive jamming techniques simulated in *RADGUNS* shall include passive reflector, simple repeater, range gate walk-off, inverse gain and swept audio.

e. A passive reflector shall be modeled by calculating the reflected signal from the reflector, which competes with the target signal at the threat radar. The reflector radar signature shall be characterized by a single-value RCS input by the user.

f. A simple repeater shall be modeled using a repeater gain and a fixed repeater delay to retransmit the victim radar's incoming pulses.

g. Range gate walk-off shall be modeled as a repeater employing a three-phase delay function consisting of a dwell phase, a walk-off (increasing delay) phase, and an off phase. The delay function shall be characterized by user inputs including phase lengths and minimum and maximum delay times. The repeater delay during the walk-off portion of the cycle will increase in either a linear or parabolic fashion, as selected by the user.

h. Inverse gain jamming shall be modeled using a square-wave jamming signal transmitted at a 50% duty cycle, 180-deg out of phase with the intercepted radar signal amplitude envelope.

i. Swept audio jamming shall be modeled using a linear frequency modulated waveform to determine a jammer output pulse train. The user shall have the capability to define the sweep period and the upper and lower frequency bounds of the waveform.

j. A sinusoidal amplitude modulation shall be added to the jammer output signal for active deceptive techniques, at the option of the user. The user shall be able to define the period and the magnitude of the modulation.

2.8.2 Functional Element Design Approach

This section describes the design approach that satisfies the requirement in Section 2.8.1 and the general ECM requirements in Section 2.5.1. The design approach used to implement on-board deceptive ECM has some elements in common with the approach for On-board Noise ECM, FE 1.3.1.1. Portions of the approach that are described for on-board noise ECM are not repeated here. Refer to Section 2.5.2 and the associated design elements for additional information.

Design Element 8-1: Jamming Criteria

For a discussion of the criteria used to determine when a jammer becomes active, see Design Element 5-4. Note: The criteria for beginning and ending jamming apply to the passive reflector, as well as to the active deceptive jamming techniques. Such criteria are not meaningful unless they signify a deployment of the reflector from an internal or out-of-detection-range location.

Design Element 8-2: Signal at Radar Receiver

The signal power received at the victim radar receiver depends on the deceptive technique employed. For a passive reflector, the threat radar's signal arriving at the reflector is reflected back to the radar receiver, as with any other target. The power at the radar receiver can be calculated using the (two-way) radar range equation, [2.5-10], with the radar cross section (RCS) of the reflector substituted for the target radar cross section (.

For a repeater, the radar signal received by the jammer is amplified by the internal repeater gain and retransmitted by the jammer. The resulting signal at the radar receiver can be computed using Equation [2.5-3], where the jammer power P_J, is given by the product of the radar signal received at the jammer receiver, S_{RJ}, and the internal repeater gain, G_{rptr}. Here S_{RJ} is given by Equation [2.5-7]. Before using the repeater output $S_{RJ}\,G_{rptr}$ in [2.5-3], it is bounded by the maximum jammer transmit power. This results in:

$$P_J = max\{S_{RJ} G_{rptr}, P_{Jmax}\} \qquad [2.8\text{-}1]$$

where:
- P_J = repeater signal at the radar receiver (W)
- S_{RJ} = radar power at the jammer receiver (W), from [2.5-7]
- G_{rptr} = repeater internal gain
- P_{Jmax} = maximum jammer power

An optional sinusoidal amplitude modulation can also be applied to P_J. The procedure for modulating the output before using it in Equation [2.5-3] is the same as that used for noise ECM, and is described in Design Element 5-1. The method outlined above applies to both the simple repeater and the more complex range gate walk-off technique.

For both the inverse gain and swept audio techniques, the jamming signal is turned on and off based on a strategy associated with the particular jamming technique. The timing of the jamming signal for these techniques is discussed in Design Element 8-6. When the jamming signal is being transmitted, the magnitude of the signal is determined by the nominal jammer power, a user input. Amplitude modulation may be applied, at the option of the user, as described in Design Element 5-1. The resulting transmitted power is then used in Equation [2.5-3] to compute the signal power at the radar receiver.

Design Element 8-3: Effective Portion of Jammer Bandwidth

For each of the deceptive jamming techniques, the jammer bandwidth used in Equation [2.5-3] is set equal to the radar receiver noise bandwidth, so that the effective jammer bandwidth is the actual bandwidth and the ratio is unity.

Design Element 8-4: Range to Jammer

The equation for calculating the range from the radar to the jammer at each pulse is Equation [2.5-6], shown in Design Element 5-3.

Design Element 8-5: Timing Relationships

<u>RGWO Repeater</u>. *RADGUNS* implements a walk-off function that consists of three phases, as shown in Figure 2.8-4. The repeater is on during the first two phases, and responds to an incoming pulse using a walk-off delay time. The walk-off delay time is discussed in Design Element 8-6. The timing of the cycle segments is defined by user-input parameters such as the dwell time, walk-off time, and off time between walk-off scans.

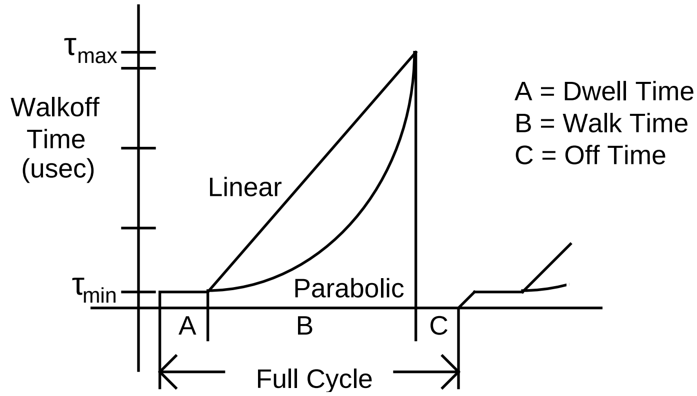


FIGURE 2.8-4. Walk-off Functions.

Times used to define the portions of the walk-off cycle are determined by:

$$\begin{aligned} T_1 &= T_0 + T_{DWELL} \\ T_2 &= T_1 + T_{WALK} \\ T_3 &= T_2 + T_{OFF} \end{aligned} \qquad [2.8\text{-}2]$$

where:
- T_{DWELL} = duration of dwell cycle (s)
- T_{WALK} = duration of variable delay cycle (s)
- T_{OFF} = duration of jammer off cycle (s)
- T_0 = simulation time at beginning of current full walk-off cycle (s)
- T_1 = simulation time at end of dwell cycle (s)
- T_2 = simulation time at end of variable delay cycle (s)
- T_3 = simulation time at end of off cycle (s)

The repeater is on from T_0 to T_2, and off between T_2 and T_3.

Two of the *RADGUNS* deceptive jamming techniques require the jammer to cycle on and off in response to the known or estimated conical scan rate of the threat target tracking radar. Inverse gain jamming employs an on-off cycle the same length as the scan rate, such that the jammer is on when the target signal at the radar is at a minimum. Swept audio jamming employs a series of pulse trains, where the pulse widths are decreasing and are determined by a linear frequency modulated waveform with frequency varying over an estimated range of radar scan frequencies.

Inverse Gain Technique. To determine the timing for inverse gain jamming, the jammer observes the incoming signal from the radar over the course of a scan period, and notes when the minimum and maximum amplitudes occur. An on cycle begins a quarter of a scan period after each maximum, and the length of each on cycle is one-half of the scan period. Figure 2.8-5 shows the relationship of the received signal to the jammer output.

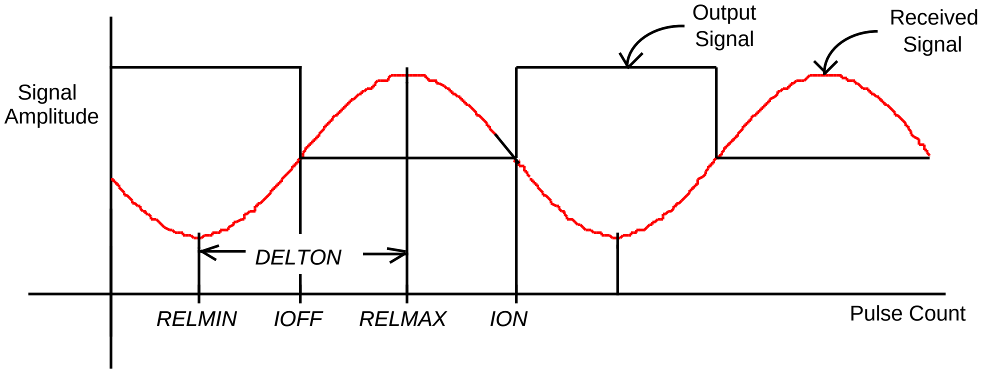


FIGURE 2.8-5. Inverse Gain Jammer Timing Relationships.

Because the jammer duty cycle is keyed to the incoming signal from the radar, the timing relationships are implemented in terms of an integer pulse count, rather than a continuous time scale. The jammer on cycle, in pulses, is of duration:

$$DELTON = \frac{N}{2} \qquad [2.8\text{-}3]$$

where: $DELTON$ = number of pulses in jammer on cycle
N = number of pulses in radar scan period

The first pair of on and off pulses is set by:

$$\left.\begin{aligned} I_{ON} &= J_{MAX} + \frac{DELTON}{2} \\ I_{OFF} &= I_{ON} + DELTON \end{aligned}\right\} \quad \text{if } J_{MAX} > J_{MIN}$$

$$\left.\begin{aligned} I_{OFF} &= J_{MIN} + \frac{DELTON}{2} \\ I_{ON} &= I_{OFF} + DELTON \end{aligned}\right\} \quad \text{if } J_{MAX} \le J_{MIN} \qquad [2.8\text{-}4]$$

where:

I_{ON} = pulse for next jammer on event
I_{OFF} = pulse for next jammer off event
J_{MAX} = pulse on which first maximum signal occurred
J_{MIN} = pulse on which first minimum signal occurred
$DELTON$ = number of pulses in jammer on cycle

After the initial on and off pulses are set, subsequent on and off pulses are reset as each jammer on or off event occurs, using:

$$\begin{aligned} I_{ON} &= I_{OFF} + DELTON \\ I_{OFF} &= I_{ON} + DELTON \end{aligned} \qquad [2.8\text{-}5]$$

Swept Audio Technique. The swept audio technique uses a positive sweeping sawtooth frequency modulation waveform as shown in Figure 2.8-3a. This sawtooth waveform produces a jammer output signal that consists of a train of pulses of decreasing width as shown in Figure 2.8-3b.

The slope of the frequency modulated waveform is calculated as:

$$SLOPE = \frac{\Delta frequency}{\Delta time} = \frac{f_u - f_l}{T_S} \qquad [2.8\text{-}6]$$

where: f_u = upper CONSCAN frequency limit (Hz)
f_l = lower CONSCAN frequency limit in (Hz)
T_S = frequency sweep period (s)

The current frequency of the modulation waveform can be calculated as:

$$f_m = f_l + (T - t_0)SLOPE \qquad [2.8\text{-}7]$$

where: f_m = current frequency of modulation waveform (Hz)
f_l = lower frequency of modulation waveform (Hz)
T = simulation time (s)
t_0 = start time of current frequency sweep (s)
$SLOPE$= rate of frequency sweep (Hz/s), from [2.8-6]

The output waveform consists of on-off pulse cycles varying in duration, as determined by the inverse of the frequency from the frequency modulation waveform. The on-off cycles are determined as follows: The first cycle begins at the jamming initiation time. The total length of the cycle is $1/f_l$, with the jammer on during the first half of the cycle and off during the second half on the cycle. At the completion of each cycle, a new on-off cycle is immediately begun, having total cycle time $1/f_m$, where f_m is the frequency of the modulation waveform at the beginning of the cycle. The jammer is on during the first half of the cycle, and off during the second half. When the frequency sweep period ends, a new on-off pulse train is begun, with the first cycle length determined by f_l as before.

Design Element 8-6: Signal Delay

The signal processing function for the tracking radar is performed in subroutine RCVRT. RCVRT requires a delay time for the jamming signal, measured from the time a pulse is transmitted by the victim radar to the time the corresponding jamming response is received by the radar receiver. The calculated delay time depends on the specific jamming technique.

Passive Reflector, Inverse Gain, Swept Audio. For these jamming techniques, this delay time is the time for a signal to travel from the radar to the jammer and return, which is given by:

$$t_{return} = \frac{2R_{RJ}}{c} \qquad [2.8\text{-}8]$$

where: R_{RJ} = range from the radar to the jammer (m)
c = velocity of light constant (m/s)

Simple Repeater. For a simple repeater, the total delay is given by the signal travel time plus the repeater delay:

$$t_{return} = \frac{2R_{RJ}}{c} + t_d \qquad [2.8\text{-}9]$$

where t_d is a fixed delay time and is a characteristic of the repeater.

RGWO Repeater. The *RADGUNS* range gate walk-off deceptive technique adds a variable programmed repeater delay to the signal transit time during the portion of the cycle that the jammer is transmitting. During the transmit segments, the total delay is given by:

$$t_{return} = \frac{2R_{RJ}}{c} + F_d(T) \qquad [2.8\text{-}10]$$

where: R_{RJ} = range from the radar to the jammer (m)
c = velocity of light constant (m/s)
T = simulation time (s)
F_d = repeater walk-off delay function, defined below

RADGUNS implements a walk-off function that can be either linear or parabolic and is defined by user-input parameters such as the minimum pulse delay from received pulse to transmitted pulse, the maximum pulse delay, the dwell time, walk-off time, and off time between walk-off scans as shown in Figure 2.8-4. Times defining the cycle segments are given by [2.8-2].

During the dwell portion of the walk-off cycle (T_0 to T_1), the repeater delay time $F_d(T)$ is set to the minimum pulse delay ($_{min}$. For a linear walk-off function, the delay time during the walk-off portion of the cycle (T_1 to T_2) is determined by the equation of a straight line passing through the points (T_1, ($_{min}$) and (T_2, ($_{max}$). The equation for the line is:

$$F_d = \tau_{min} + a(T - T_1) \qquad [2.8\text{-}11]$$

where a is the slope of the line, given by:

$$a = \frac{\tau_{max} - \tau_{min}}{T_{WALK}} \qquad [2.8\text{-}12]$$

where: $(_{max}$ = maximum delay time (s)
$(_{min}$ = minimum delay time (s)
T = simulation time (s)
T_1 = start time for walk-off cycle (s)
T_{WALK} = duration of walk-off cycle, or walk time (s)

For a parabolic walk-off function, the repeater delay time during the walk-off portion of the cycle is given by the equation of a parabola passing through the two points (T_1, $(_{min}$) and (T_2, $(_{max}$). The equation for the parabola is:

$$F_d = \tau_{min} + a(T - T_1)^2 \qquad [2.8\text{-}13]$$

where the coefficient a is given by:

$$a = \frac{\tau_{max} - \tau_{min}}{T_{WALK}^2} \qquad [2.8\text{-}14]$$

During the final portion of the walk-off cycle, the repeater is off. The off cycle begins at the end of the linear or parabolic variable-delay cycle and has duration T_{OFF}, or off time.

2.8.3 Functional Element Software Design

This section contains the software design necessary to implement the FE requirements described in Section 2.8.1, and the design approach outlined in Section 2.8.2. It is organized as follows: the first part describes the subroutine hierarchy and gives descriptions of the relevant subroutines; the next part contains logical flow charts and describes important operations represented by each block in the chart; the last subsection contains a description of all input and output data for the FE as a whole and for each subroutine that implements the On-board Deceptive ECM FE.

Some of the software employed to implement the On-Board Deceptive ECM FE is identical to that of the On-Board Noise ECM FE. The design of that software is discussed in Section 2.5.3.

Subroutine On-Board Deceptive ECM Design

Figure 2.8-6 shows the calling sequence of the On-Board Deceptive ECM FE within the entire *RADGUNS* v.2.0 model structure. Functions which implement the FE are in shaded blocks. Each of these subroutines is briefly described in Table 2.8-1. Subroutines which directly implement the On-Board Deceptive functional element appear in shaded blocks.

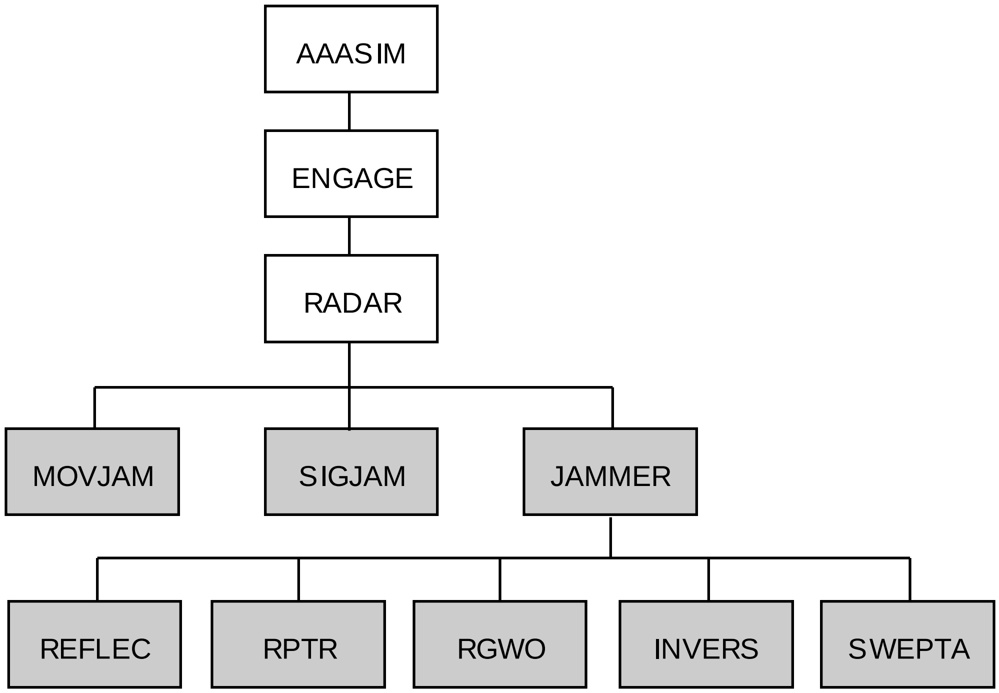


FIGURE 2.8-6. Subroutine Call Hierarchy for On-Board Deceptive ECM.

TABLE 2.8-1. Module Description for On-Board Deceptive ECM.

Module	Description
AAASIM	Main routine to simulate AAA system
ENGAGE	Controls system while in tracking mode
RADAR	Calculates signals from target, clutter and jammers, and sums them in the receiver
MOVJAM	Calculates location and velocity of all active jammers
SIGJAM	Computes the antenna gain in the direction of active jammers
JAMMER	Generates jammer signals for up to ten simultaneous jammers
REFLEC	Simulates the effect of a passive reflector
RPTR	Simulates a straight-through repeater jammer
RGWO	Simulates a range gate walk-off jammer
INVERS	Simulates an inverse gain jammer
SWEPTA	Simulates a swept audio jammer

The functional flow diagram shown in Figure 2.5-2 displays the effect of the ECM FE on the logical flow of subroutine RADAR. RADAR calls each of the subroutines MOVJAM, SIGJAM and JAMMER for each pulse, to calculate the jammer input to the radar receiver.

Subroutine SIGJAM calculates the radar antenna gains (both transmit and receive) in the direction of any active jammers. This subroutine is addressed in Section 2.20, Antenna Gain, and in Section 2.21, Antenna Scan.

In an effort to make the ECM FE system independent, the radar receive antenna gain is applied to the jammer signal after it is returned from subroutine JAMMER. Thus the computation of the jammer signals at the radar receiver in the individual technique subroutines by Equation [2.5-3] or [2.5-10] does not include the radar receiver gain factor. The ECM FE is implemented just prior to the summing of signals in the radar receiver in subroutine RCVRT.

Logical Flow for Subroutine MOVJAM. Subroutine MOVJAM updates the position of each jamming source. Subroutine MOVJAM, as it applies to an on-board jammer, is described in functional element 1.3.1.1, On-Board Noise ECM, in Section 2.5.3.

Logical Flow for Subroutine JAMMER. Subroutine JAMMER generates instantaneous jamming signals as a function of time for up to ten simultaneous jammers. It is called by subroutine RADAR just prior to processing each radar pulse in the threat radar receiver. A subroutine flow chart is shown in Figure 2.8-7. The flow chart shows only those portions of JAMMER relating to deceptive jamming. A version of subroutine JAMMER specific to noise jamming is included in the On-Board Noise FE, Section 2.5.3.

Subroutine JAMMER returns the jammer power, return time, frequency, Doppler shift, and pulse width of the jammer return, in the signal environment array *SIGENV*. Array *JAMSRC* holds the type of jamming signal; the value *"SIG"* is returned for each of the deceptive jamming subroutines. It is used in subroutine RCVRT to set the range gate. The associated return time for a specific deceptive technique may or may not be within the range gate. All of these values are actually calculated in the technique subroutines called by JAMMER.

It is possible for an active jammer to have no return. Arrays SIGENV and JAMSRC hold values only for jammers having returns (non-zero signals). The jammer pointer JAMPTR indicates the array elements corresponding to the latest jammer having a return. The array *JAMNUM* is used to indicate which jammer is responsible for each signal.

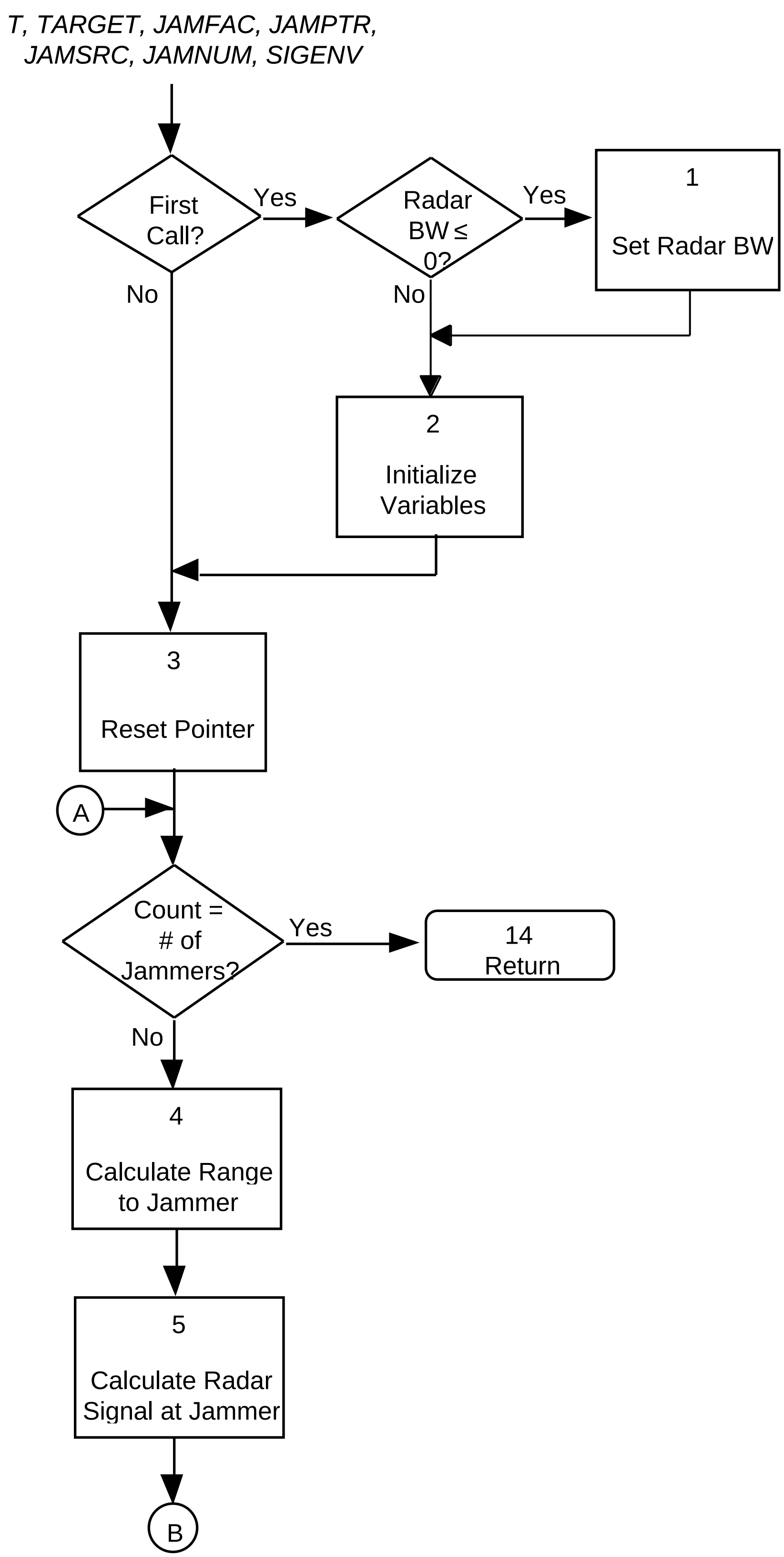


FIGURE 2.8-7. Subroutine JAMMER Flow Chart.

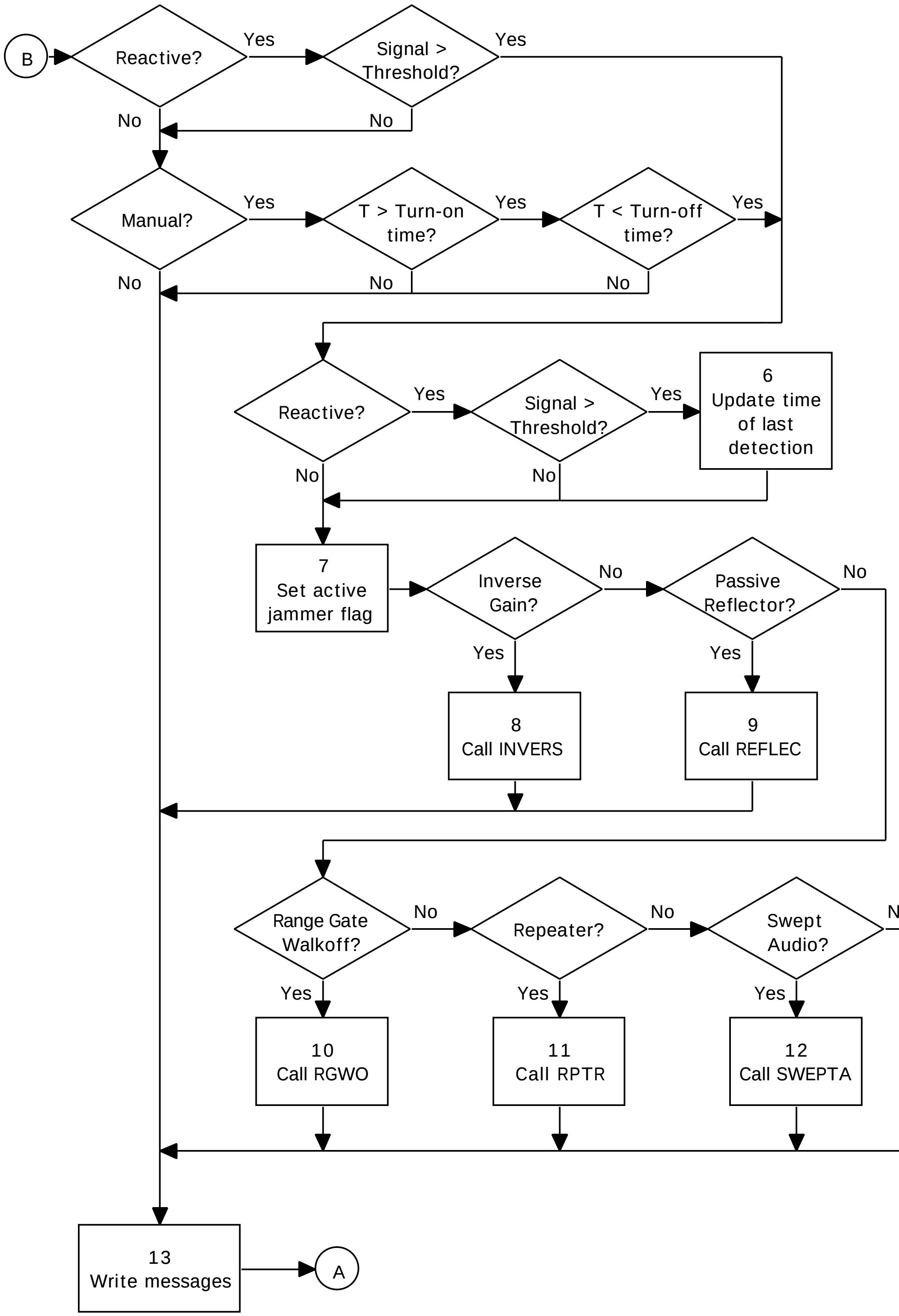


FIGURE 2.8-7. Subroutine JAMMER Flow Chart. (Contd.).

Blocks 1 and 2 are initializations performed the first time subroutine JAMMER is called.

Block 1. If the threat radar bandwidth *RDRBW* has not yet been initialized (is less than or equal to zero), it is set to 6 MHz.

Block 2. The user may specify up to ten jammers. Arrays *FIRSTJ*, *FIRSTR*, and *JAMMED* are ten element arrays, each element of which corresponds to a separate jammer. For the number of jammers specified by the user (*NUMJAM*), the following flags and variables are initialized. *FIRSTJ* flags are set to indicate that jamming has been initiated, *FIRSTR* flags are set to indicate that the technique local variables need to be reset, and *JAMMED* flags are cleared to indicate that the jammers are not yet active. The array *JAMTIM*, marking the last time a reactive jammer detected the incoming threat radar signal, is initially set to a large value. For a reactive jammer, a .5-s period is allowed, after the most recently detected signal, before jamming is discontinued.

Block 3. The current jammer pointer, *JAMPTR*, is reset to zero each time subroutine JAMMER is called. Blocks 4 through 13 are executed once for each jammer input by the user.

Block 4. The range from the radar to the current jammer is calculated using Equation [2.5-6] and stored in *JAMRG*.

Block 5. The radar signal at the jammer receiver, *PJAMRX*, is calculated with Equation [2.5-7].

Blocks 6-7. If the user has selected the reactive jamming mode and the jammer receiver threshold has been exceeded, or if manual mode has been selected and the simulation time exceeds the turn on time but does not exceed the turn off time, the *JAMMED* flag corresponding to the current jammer is set to indicate that jammer is active. In the reactive case, if the radar signal exceeds the threshold, the time of the most recent signal detection is updated (*JAMTIM*). If jamming is not active, execution resumes with Block 13.

Blocks 8-12. Subroutines REFLEC, RPTR, RGWO, INVERS, and SWEPTA simulate passive reflector, simple repeater, range gate walk-off, inverse gain, and swept audio jammers respectively. The appropriate subroutine is called based on the jamming technique specified by the user in *JAMTYP*. If the jammer signal is a non-zero value, the technique subroutine updates the jammer signal environment array (*SIGENV*), the type of jamming signal (*JAMSRC*), the mapping array *JAMNUM* (the index of the jammer that produced the signal), and the array pointer for this jammer signal (*JAMPTR*).

Block 13. If the current jammer has just become active, subroutine EVENT is used to record a “jamming initiated” event. The jammer number, class and type, as well as the time jamming was initiated are written to both the screen and the output file. If a reactive jammer is active and the jammer received power has failed to exceed the threshold for .5-s in reactive mode, or the simulation time exceeds the turn off time for a manually-employed jammer, subroutine EVENT records a “jamming ended” event. The jammer number, class, type, and time that jamming ended are written to both the screen and the output file. The active jamming flag is set to “false”, and the *FIRSTJ* flag is reset to “true”.

Block 14. If signals have been calculated for each active jammer, control returns to subroutine RADAR where each jammer signal is amplified by the threat radar receive antenna gain and processed with the other radar returns in the receiver.

Logical Flow for Subroutine REFLEC. Subroutine REFLEC calculates the jammer signal and return time for a passive reflector. Subroutine JAMMER calls REFLEC at each pulse, for each passive reflector jamming source. The logical flow of subroutine REFLEC is shown in Figure 2.8-8 and is described below.

Block 1. The reflector signal at the radar receiver is calculated using Equation [2.5-10].

Blocks 2 and 3. If the received signal is non-zero, function INCJAM is used to increment the current jammer pointer (*JAMPTR*). The signal return time is calculated as in Equation [2.8-8]. The reflector power at the radar receiver and the return time are stored in the jammer portion of the signal environment array (*SIGENV*). The frequency, Doppler shift, and pulse width of the target return from array *SIGENV* are each used to set the corresponding elements of the jammer return (also stored in array *SIGENV*). The reflector signal type and the jammer number are saved in arrays *JAMSRC* and *JAMNUM*.

Block 4. Control returns to subroutine JAMMER.

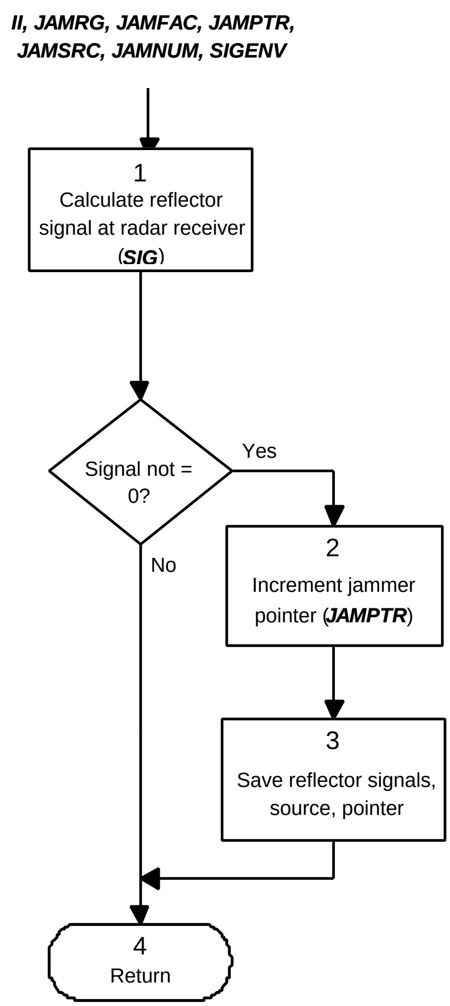


FIGURE 2.8-8. Subroutine REFLEC Flow Chart.

Logical Flow for Subroutine RPTR. Subroutine RPTR calculates the jammer signal and return time for a simple repeater. Subroutine JAMMER calls RPTR at each pulse, for each repeater jamming source. The logic flow of subroutine RPTR is shown in Figure 2.8-9 and is described below.

Block 1. If subroutine RPTR has not been called previously for the current jammer, the jammer bandwidth (*JXBW*) is set to the radar bandwidth (*RDRBW*). *FIRSTR* is set to false, signaling the first call to the subroutine for this jammer has now been made.

Block 2. The received threat radar signal (*PJAMRX*) is amplified by the internal jammer gain input by the user (*JXGAIN*).

Block 3. If the amplified signal exceeds the user-specified maximum jammer transmitter power level, it is limited to the maximum (*JXMAXP*).

Block 4. If the user has specified a modulation index, the signal is amplitude-modulated as described in Section 2.5.2, Equations [2.5-4] and [2.5-5].

Block 5. The jammer signal at the radar receiver (*SIG*) is calculated using Equation [2.5-3].

Blocks 6 and 7. If the received jammer signal is non-zero, function INCJAM is used to increment the jammer pointer. The jammer signal return time incorporating the user-specified repeater delay is calculated with Equation [2.8-9]. The jammer signal at the radar receiver and the return time are stored in the jammer portion of the signal environment array (*SIGENV*). The frequency, Doppler shift, and pulse width of the target return from array *SIGENV* are each used to set the corresponding elements of the jammer return (also stored in array *SIGENV*). The jammer signal type and number are stored in arrays *JAMSRC* and *JAMNUM*.

Block 8. The signal environment array and other parameters are returned to subroutine JAMMER.

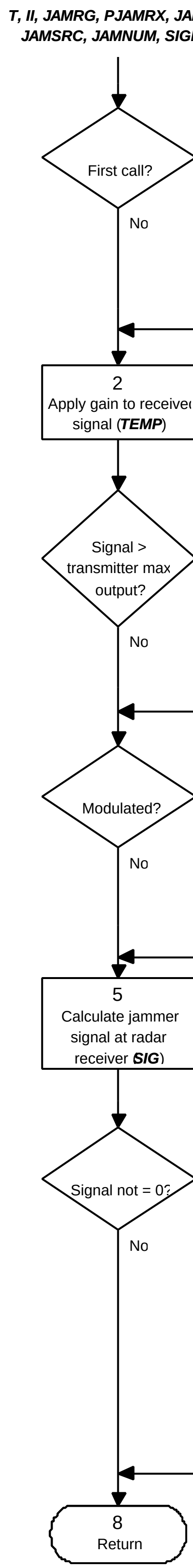


FIGURE 2.8-9. Subroutine RPTR Flow Chart.

Logical Flow for Subroutine RGWO. Subroutine RGWO calculates the jammer signal and return time for a range gate walk-off jammer. Subroutine JAMMER calls RGWO at each pulse, for each range gate walk-off jamming source. The logic flow of subroutine RGWO is shown in Figure 2.8-10 and is described below.

Blocks 1 and 2. If subroutine RGWO has not been called previously for the current jammer, several variables need to be initialized. *FIRSTR* is set to false, signaling the first call to the subroutine for this jammer has now been made. The jammer bandwidth (*JXBW*) is set to the threat radar bandwidth (*RDRBW*). The walk start time *(RNGTIM(1))* is set to the current time plus the user-specified dwell time, the walk end time *(RNGTIM(2))* is set to the start time plus the user-input walk time, and the end of cycle time *(RNGTIM(3))* is set to the walk end time plus the user-defined off time. If a linear walk function is requested, the slope of the linear portion is defined as in Equation [2.8-12]. If instead a parabolic walk function is selected, the constant coefficient is defined using Equation [2.8-14].

Block 3. If the current time exceeds the end of cycle time, the walk start and end times, and the end of cycle time are updated for the next cycle.

Block 4. If the current time exceeds the walk end time (but not the cycle time), the jammer output (*TEMP*) is set to zero.

Blocks 5-6. If the current time exceeds the walk start time, but not the walk end time, the delay of the jammer signal is calculated (*TDELAY*) using either Equation [2.8-11] or [2.8-13], depending on if the function is linear or parabolic.

Block 7. The jammer transmitted signal is then set to the received threat radar signal amplified by the internal jammer gain.

Block 8 and 9. If the current time has not exceeded the walk start time, the function is in the dwell phase and the jammer transmitted signal is set to the received signal amplified by the internal jammer gain delayed by the minimum delay.

Block 10. If the amplified signal exceeds the user-specified maximum jammer transmitter power level, it is limited to the maximum (*JXMAXP*) as in Equation [2.8-1].

Block 11. If the user has specified a modulation index, the signal is amplitude-modulated as described in Section 2.5.2, On-Board Noise ECM, Equations [2.5-4] and [2.5-5].

Block 12. The jammer signal at the radar receiver (*SIG*) is calculated using Equation [2.5-3].

Blocks 13 and 14. If the received jammer signal is non-zero, function INCJAM is used to increment the jammer pointer. The jammer signal return time is calculated using Equation [2.8-10]. The jammer signal at the radar receiver and the return time are stored in the jammer portion of the signal environment array (*SIGENV*). The frequency, Doppler shift, and pulse width of the target return from array *SIGENV* are each used to set the corresponding elements of the jammer return (also stored in array *SIGENV*). The jamming type and jammer index are stored in arrays *JAMSRC* and *JAMNUM*.

Block 15. The signal environment array and other parameters are returned to subroutine JAMMER.

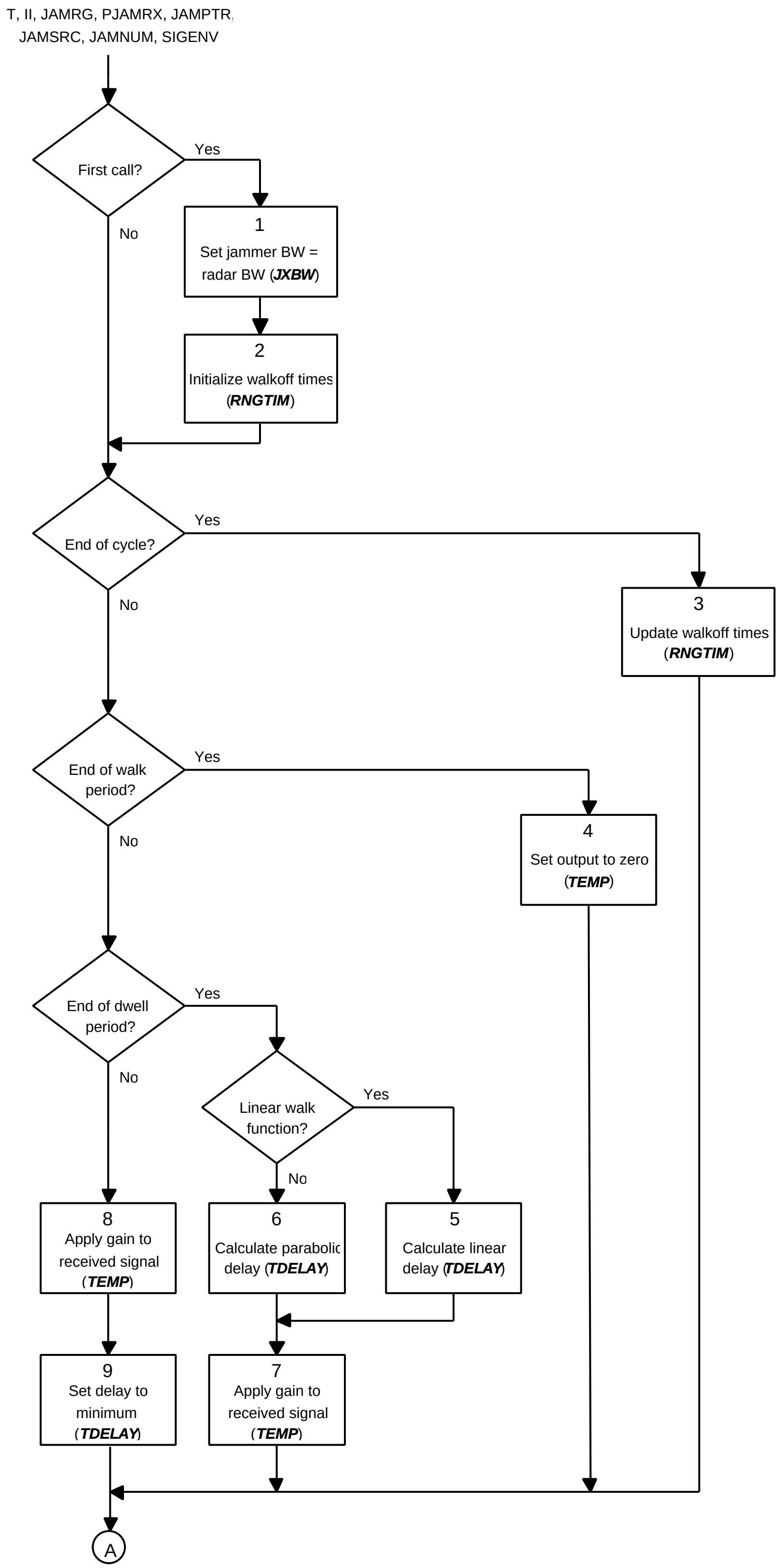


FIGURE 2.8-10. Subroutine RGWO Flow Chart.

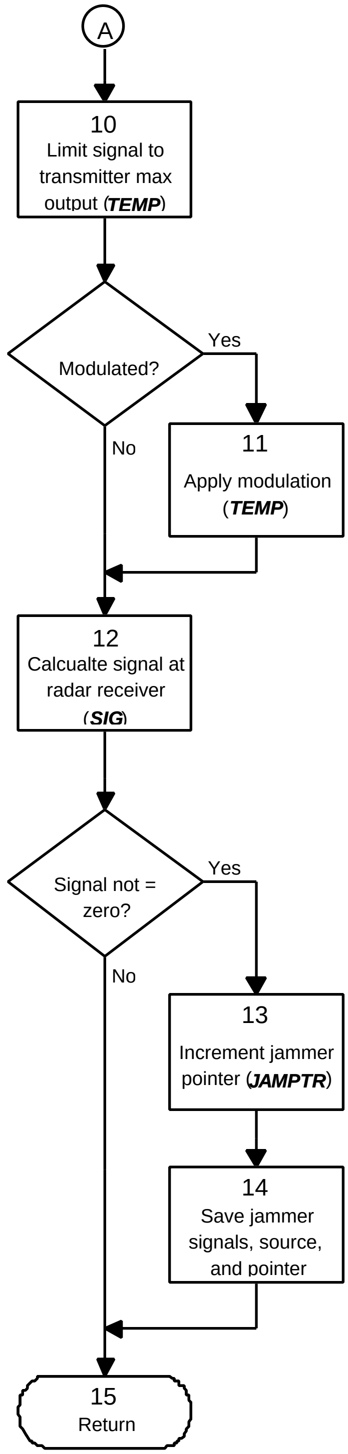


FIGURE 2.8-10. Subroutine RGWO Flow Chart. (Contd).

Logical Flow for Subroutine INVERS. Subroutine INVERS calculates the jammer signal and return time for an inverse gain jammer. Subroutine JAMMER calls INVERS at each pulse, for each inverse gain jamming source. The logic flow of subroutine INVERS is shown in Figure 2.8-11 and is described below.

Block 1. If subroutine INVERS has not been previously called for the current jammer, several variables need to be initialized. The minimum and maximum of the incoming scan pattern must be determined so that the jammer signal can be transmitted 180-deg out of phase with the received radar signal. Several variables are used to describe the incoming radar signal. *JPLS* is the received signal pulse counter. *JSTART* marks the initial pulse in the scan period that is inspected to determine the minimum and maximum signal power. *JMIN* and *JMAX* are pulse markers indicating the current location of the minimum and maximum signal levels. The jammer output signal is characterized by *IOFF* and *ION*, pulse counts that signal the start of the jammer off and on periods, and *DELTON* which maintains a 50% jammer duty cycle. All of these variables are set to zero the first time subroutine INVERS is called for each jammer. *RELMIN* and *RELMAX*, which hold the scan minimum and maximum signal levels, are initialized to 10^{20} and ^{20}, respectively. *TSTART*, the time that the current jammer became active, is set to the current simulation time. *FIRSTR* is set to false, signaling the first call to the subroutine for this jammer has now been made. The jammer bandwidth, *JXBW*, is set to the radar bandwidth, *RDRBW*.

Block 2. The pulse count of the received signal, *JPLS*, is incremented each time subroutine INVERS is called. If the duty cycle *DELTON* is not zero, a minimum and maximum for the scan have already been found and execution continues with Block 16.

Block 3. If the duty cycle variable is zero, the transmitted power is set to zero.

Block 4. If 2 s have not passed since the jammer went active, execution continues with Block 15. The 2-s delay allows the radar time to develop angular error. If 2 s have passed, the scan period start is marked by setting *JSTART* to the current value of the pulse counter *JPLS*.

Blocks 5-10. If the incoming signal has been measured over the first scan period, the maximum and minimum signal levels have been determined, and the duty cycle variable (*DELTON*) is set to one-half the number of pulses in a conical scan period. The pulse markers for the first on and off pulses (*ION* and *IOFF*) are set, depending on if the minimum or maximum signal level occurred first in the inspected scan cycle, as in Equations [2.8-4]. To produce a 180-deg out-of-phase signal, the jammer should transmit during the radar's minimum modulation period and turn off otherwise (50% duty cycle).

If the maximum signal followed the minimum, the first event is an on pulse, occurring one-half of the jamming duty cycle (one-quarter of a scan period) after *JMAX*. If the maximum signal occurred first, the first event is an off pulse, *IOFF*, set to *JMIN* plus one-half of the jamming duty cycle. The next event (*IOFF* or *ION*, respectively) occurs one duty cycle later.

Note that in the case of *JMIN* larger than *JMAX*, the first on pulse does not occur until one-fourth to three-fourths scan periods after the end of the inspected scan period.

Blocks 11-12. If the signal is still being measured during the first scan period, and the current received signal is greater than the previous maximum signal (*RELMAX), JMAX* is set to the current pulse count to signal a new maximum and *RELMAX* is updated to hold the new maximum.

Blocks 13-14. If the current received signal is less than the previous minimum signal (*RELMIN)*, *JMIN* is set to the current pulse count to signal a new maximum and *RELMIN* is updated to hold the new maximum.

Block 15. If the duty cycle has not yet been set, the jammer output is set to zero (*TEMP*) and execution continues with Block 20.

Blocks 16-17. If the maximum and minimum for the scan have been found, the output waveform has been characterized by *ION* and *IOFF*. If the current pulse count (*JPLS*) is greater than or equal to the next off pulse, the transmitted power is set to zero, and the off pulse marker is advanced by one full scan period.

Blocks 18-19. If the current pulse count is greater than or equal to the next on pulse, the transmitter power is set to the nominal jammer power (*JXPWR*) and the on pulse counter is incremented by one scan period.

Block 20. If the user has input a modulation index, the jammer output is amplitude-modulated as described in Section 2.5.2, Equations [2.5-4] and [2.5-5].

Block 21. The jammer signal at the radar receiver is calculated using Equation [2.8-3].

Blocks 22 and 23. If the received signal is non-zero, function INCJAM is used to increment the current jammer pointer (*JAMPTR*). The return time of the jammer signal is calculated as in Equation [2.8-8]. The jammer signal at the radar receiver and the return time are stored in the jammer portion of the signal environment array (*SIGENV*). The frequency, Doppler shift, and pulse width of the target return from array *SIGENV* are each used to set the corresponding elements of the jammer return (also stored in array *SIGENV*). The type of signal and the jammer signal number are stored in *JAMSRC* and *JAMNUM*, respectively.

Block 24. The signal environment array, type of jammer, signal number and jammer pointer are returned to subroutine JAMMER.

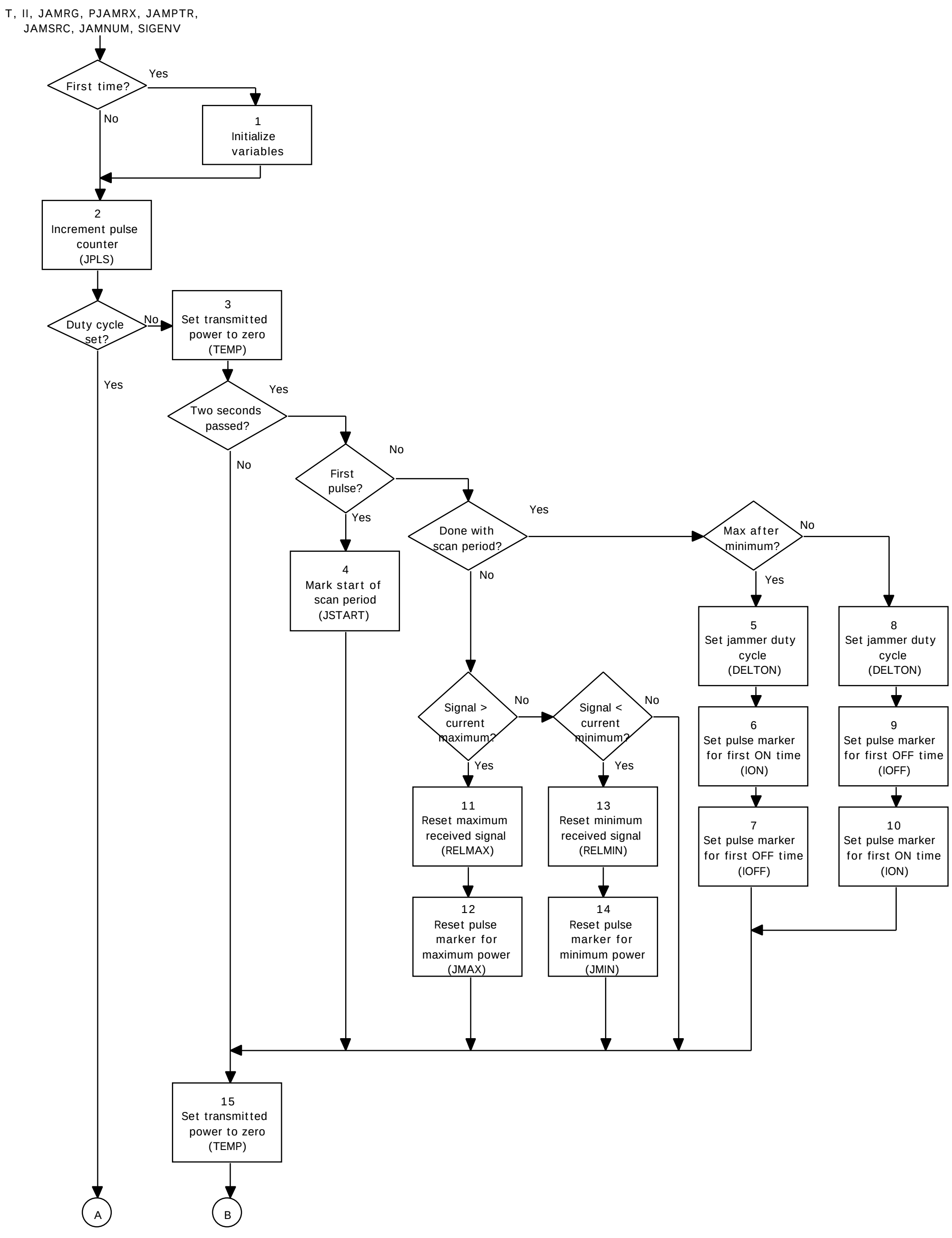


FIGURE 2.8-11. Subroutine INVERS Flow Chart.

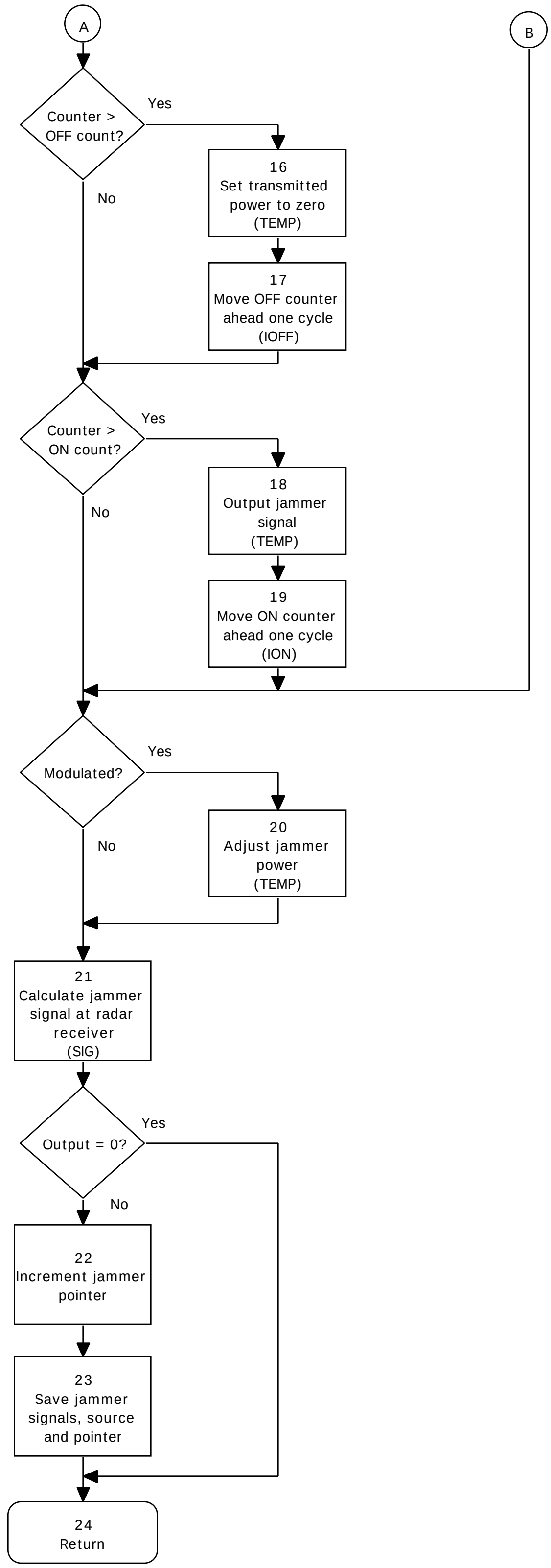


FIGURE 2.8-11. Subroutine INVERS Flow Chart. (Contd).

Logical Flow for Subroutine SWEPTA. Subroutine SWEPTA simulates a swept audio jamming technique that can also be amplitude modulated. Subroutine JAMMER calls SWEPTA at each pulse, for each swept audio jamming source, and SWEPTA calculates the jammer signal and return time. The logic flow of subroutine SWEPTA is shown in Figure 2.8-12 and is described below.

Block 1. Several technique-specific parameters need to be initialized the first time subroutine SWEPTA is called for each jammer. The frequency of the jammer signal (*JXFREQ*) is initialized to the target signal frequency (*SIGENV(0,3)*). The jammer bandwidth (*JXBW*) is set to the radar bandwidth (*RDRBW*). The slope of the frequency modulation waveform (*SLOPE*) is calculated using Equation [2.8-6] with *SWEEPF(1)* and *SWEEPF(2)* as the lower and upper frequency limits, and *JXPER* as the sweep period. *FIRSTR* is set to false, signaling the first call to the subroutine for this jammer has now been made.

DELTON, the length of an on cycle, is initialized as one over twice the lower frequency bound. Twice *DELTON*, or one over the current frequency, then signals the end of the off period and the beginning of a new pulse cycle. Arrays *TLAST* and *PSTART* are set to the current simulation time, storing the start time of the current frequency sweep and pulse cycle, respectively.

Block 2. If the current pulse cycle has ended and a full sweep has elapsed, *DELTON* is reset based on the minimum frequency of the modulation waveform. *TLAST* and *PSTART* are set to the current simulation time, signaling the start of a new sweep and pulse cycle.

Block 3. If the current pulse cycle has ended before the sweep is complete, the current modulation frequency is calculated using Equation [2.8-7] and *DELTON* is reset as one over twice the current modulation frequency. The new pulse cycle start time is set to the current simulation time.

Block 4. The signal level of the last pulse in each cycle is set to zero (*TEMP*).

Block 5. If 50% of the pulse cycle has elapsed, the jammer output is set to zero (*TEMP*) and execution continues with Block 8.

Blocks 6 and 7. Otherwise, the jammer is transmitting. The jammer signal at the radar receiver is calculated using Equation [2.5-3]. If the user has specified a modulation index (*JXMODA*), the output signal is amplitude-modulated as described in Section 2.5.2, On-Board Noise ECM, Equations [2.5-4] and [2.5-5].

Blocks 8 and 9. If the received signal is non-zero, function INCJAM is used to increment the current jammer pointer (*JAMPTR*). The jammer signal return time is calculated with Equation [2.8-8]. The jammer signal at the radar receiver and the return time are stored in the jammer portion of the signal environment array (*SIGENV*). The frequency, Doppler shift, and pulse width of the target return from array *SIGENV* are each used to set the corresponding elements of the jammer return (also stored in array *SIGENV*). The type of signal and the jammer signal number are stored in *JAMSRC* and *JAMNUM*.

Block 10. The signal environment array, type of jammer, signal number, and jammer pointer are returned to subroutine JAMMER.

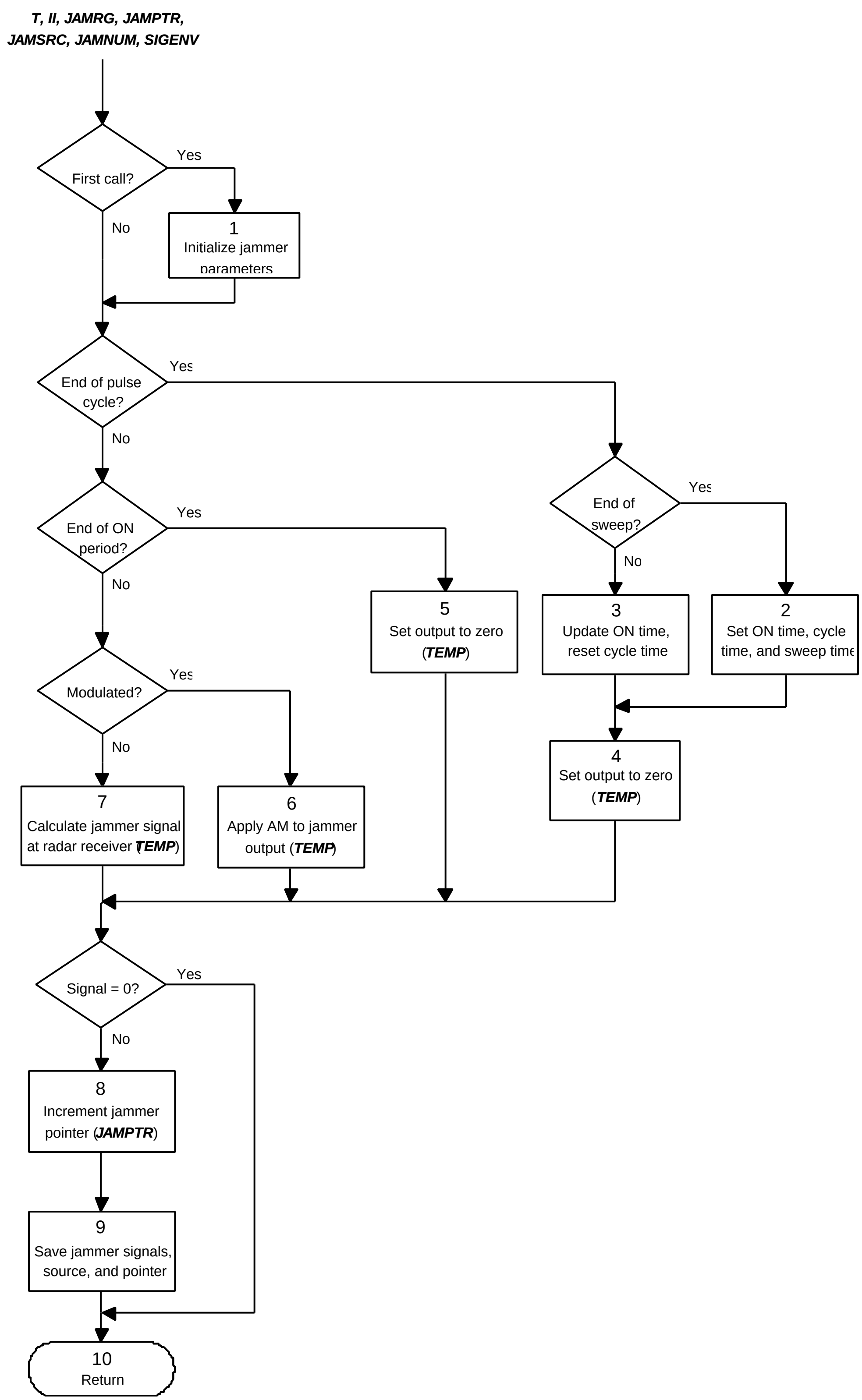


FIGURE 2.8-12. Subroutine SWEPTA Flow Chart.

Functional Element Inputs and Outputs

This section identifies the input and output data associated with the On-Board Deceptive ECM FE. Table 2.8-2 shows the FE output.

TABLE 2.8-2. Outputs of On-Board Deceptive ECM FE.

Variable Name	Description
SIGENV	Signal environment array. Specific elements output by this FE are defined below.
SIGENV(x,1)	Jammer signal at radar receiver (W)
SIGENV(x,2)	Return time (s)
SIGENV(x,3)	Jamming frequency (Hz)
SIGENV(x,4)	Doppler shift (rad/s)
SIGENV(x,5)	Jammer pulse width (s)
JAMSRC	Type of jamming signal. Deceptive jamming is coded 'SIG'
JAMPTR	Pointer showing last jammer for which a (non-zero) signal value was calculated
JAMNUM	Array mapping identifying those jammers for which a non-zero signal was computed

Tables 2.8-3 and 2.8-4 display user-defined input data which affect the On-Board Deceptive ECM FE. Table 2.8-3 gives general input parameters, while Table 2.8-4 lists technique-specific inputs and shows which techniques correspond to each parameter.

TABLE 2.8-3. General User Inputs.

Variable Name	User Options	Description
JXCLAS	SPJ - self protection jammer TOW - towed jammer or decoy EXP - expendable jammer SOJ - standoff jammer	Jammer class. SPJ is the option for on-board jamming
JAMODE	MAN - manual start/stop times REA - reactive based on received signal	Jammer employment mode
TIMJAM	Times (s)	Manual jamming turn on/turn-off times
JTHRES	dBmW (converted to W)	Jammer receiver threshold for reactive jamming
JAMTYP	INV - inverse gain RGW - range gate walk-off REF - passive reflector RPT - simple repeater SWA - swept audio	Jammer technique.

TABLE 2.8-4. Technique-Specific User Inputs.

Variable Name	Options/ Units	Unit Conversions	Description	Applicable Techniques				
				REF	RPT	RGW	INV	SWA
JXMAXP	W		Maximum transmit power of jammer		x	x	x	x
JXPWR	W		Nominal transmit power of jammer				x	x
JTXAGN	dB	linear	Jammer transmit antenna gain		x	x	x	x
JRXAGN	dB	linear	Jammer receive antenna gain		x	x	x	x
JXMODA	0-100	fraction	Modulation percentage		x	x	x	x
JXMODP	s		Modulation period		x	x	x	x
JXGAIN	m^2		Reflector RCS	x				
	dB	linear	Internal jammer gain		x	x		
AMINDL	μsec	s	Minimum delay		x	x		
AMAXDL	μsec	s	Maximum delay			x		
WALK	LIN/PAR		Walk-off function type			x		
DWELL	μs	s	Dwell time			x		
WLKTIM	μs	s	Walk time			x		
OFFTIM	μs	s	Off time			x		
SWEEPF	Hz		Sweep lower and upper frequency limits					x
JXPER	s		Sweep period					x

Some conversions of units are made within subroutine INPJAM, before variables are used in the ECM FE equations. The jammer receiver threshold is converted from dBmW to W, the jammer transmit and receive antenna gains and the internal jammer gain are converted from dB to linear numbers, the modulation percentage is converted to a fraction between 0 and 1, and times input in

Table 2.8-5 lists variables input to and output from subroutine JAMMER. The arrays *JAMPTR*, *JAMSCR*, *JAMNUM* and the jammer signal portion of array *SIGENV* are actually calculated in technique-specific subroutines called by JAMMER and are passed back to RADAR through arguments in JAMMER. The inputs *TARGET* and *JXCLAS* are used by JAMMER only for the purpose of writing event messages.

TABLE 2.8-5. Subroutine JAMMER Inputs and Outputs.

SUBROUTINE: JAMMER					
Inputs			**Outputs**		
Name	**Type**	**Description**	**Name**	**Type**	**Description**
JAMFAC	Argument	Radar antenna gain in direction of jammer, from SIGJAM	JAMPTR	Argument	Pointer showing last jammer for which a (non-zero) signal value was calculated
SIGENV	Argument	Signal environment array: passed to technique-specific subroutines	JAMSRC	Argument	Type of jamming signal. Deceptive jamming is coded 'SIG'
NUMJAM	Common	Number of jammers, initialized in INPJAM	JAMNUM	Argument	Array mapping identifying those jammers for which a non-zero signal was computed
JAMODE	Common	Jammer mode of operation: MAN (manual) or REA (reactive)	SIGENV	Argument	Signal environment array. Jammer signal values set in technique-specific subroutines and passed to RADAR
JTHRES	Common	Jammer receiver threshold (W)	FIRSTR	Common	Flags for each jammer, indicating first call to a technique subroutine
TIMJAM	Common	Manual jammer on-off times (s)	MESJAM	Common	Jamming initiation and ending character strings
JXLOC	Common	Jammer position relative to radar, computed in MOVJAM			
JRXAGN	Common	Jammer receive antenna gain			
PTX	Common	Threat radar transmitted power (W)			
WLNTH	Common	Threat radar wavelength (m)			
RDRBW	Common	Threat radar noise bandwidth (Hz)			
PI	Common	π (radians)			
FIRST	Common	FIRST(20) is the first call to JAMMER flag			
T	Argument	Simulation time (s), from RADAR			
TARGET	Argument	Target x,y,z position, velocity, and acceleration (m, m/s, m/s^2 from MOVTAR			

TABLE 2.8-5. Subroutine JAMMER Inputs and Outputs. (Contd.)

SUBROUTINE: JAMMER					
Inputs			**Outputs**		
Name	**Type**	**Description**	**Name**	**Type**	**Description**
JAMTYP	Common	ECM technique			
JXCLAS	Common	Jammer class: SPJ = on-board			

Table 2.8-6 summarizes the variables input to each of the technique-specific subroutines called by JAMMER. Many of the variables are input to several or all of the subroutines. The columns on the right side of the table show which variables apply to each subroutine.

TABLE 2.8-6. Summary of Techniques Subroutine Inputs.

Variable Name	**Type**	**Description**	**REFLEC**	**RPTR**	**RGWO**	**INVERS**	**SWEPTA**
T	Argument	Simulation time (s)		x	x	x	x
II	Argument	Index of current jammer	x	x	x	x	x
JAMRG	Argument	Range from radar to jammer (m), from JAMMER	x	x	x	x	x
JAMFAC	Argument	Radar antenna gain in direction of jammer, from SIGJAM	x				
PJAMRX	Argument	Radar power at jammer receiver (W), from JAMMER		x	x	x	
SIGENV	Argument	Signal environment array, via JAMMER	x	x	x	x	x
SIGENV(0,3)	Argument	Radar transmit frequency (Hz)	x	x	x	x	x
SIGENV(0,4)	Argument	Doppler shift (rad/s)	x	x	x	x	x
SIGENV(0,5)	Argument	Radar pulse width (s)	x	x	x	x	x
JXPWR	Common	Nominal transmit power of jammer (W)				x	x
JTXAGN	Common	Jammer transmit antenna gain		x	x	x	x
JXMAXP	Common	Maximum transmit power of jammer (W)		x	x	x	x
JXMODA	Common	Modulation fraction		x	x	x	x

TABLE 2.8-6. Summary of Techniques Subroutine Inputs. (Contd.)

Variable Name	Type	Description	REFLEC	RPTR	RGWO	INVERS	SWEPTA
JXMODP	Common	Modulation period (s)		x	x	x	x
JXGAIN	Common	Reflector RCS (m^2)	x				
		Internal jammer gain		x	x		
AMINDL	Common	Minimum delay (s)		x	x		
AMAXDL	Common	Maximum delay (s)			x		
DWELL	Common	Dwell time (s)			x		
WALK	Common	Walk-off function type			x		
WLKTIM	Common	Walk time (s)			x		
OFFTIM	Common	Off time (s)			x		
SWEEPF	Common	Sweep lower and upper frequency limits (Hz)					x
JXPER	Common	Sweep period (s)					x
PTX	Common	Radar transmitter power (W)	x				
WLNTH	Common	Radar wavelength (m)	x	x	x	x	x
RDRBW	Common	Radar noise bandwidth (Hz)		x	x	x	x
TOTLOS	Common	Radar internal signal losses	x	x	x	x	x
NPSCAN	Common	Number of pulses in threat radar scan period				x	
C	Common	Velocity of light constant (m/s)	x	x	x	x	x
PI	Common	π	x	x	x	x	x
FIRSTR	Common	Array of flags for first call to subroutine for each jammer, at this pulse		x	x	x	x

Output parameters for each of the technique subroutines are the same as the overall outputs for the On-Board Deceptive FE, as shown in Table 2.8-2, with one additional parameter. The jammer bandwidth, *JXBW*, which is set equal to the radar bandwidth, is output from each of the technique subroutines (with the exception of subroutine REFLEC) as a COMMON variable.

2.8.4 Assumptions and Limitations

Deceptive jamming techniques simulated in *RADGUNS* are limited to passive reflector, simple repeater, range gate walk-off, inverse gain and swept audio. Deceptive jamming affecting target acquisition (such as false targets) is not modeled.

The jammer antenna boresight is assumed to be aimed at the radar, and a single transmitter antenna gain value, representing the jammer main-lobe gain, is used for all jammer signal calculations. A single jammer receiver gain value is used in computing the radar signal receiver at the jammer.

For swept audio and inverse gain techniques (active, non-repeater techniques), the capability of a jammer to counter a frequency-agile radar is not addressed, and threat radar frequency agility is not modeled. *RADGUNS* assumes that the jamming signal is the same frequency and bandwidth as the radar receiver noise bandwidth throughout the engagement.

2.8.5 Known Problems or Anomalies

No problems or anomalies in the On-Board Deceptive ECM FE are known to exist at this time.